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Lanthanide(III)-Based Photonic Materials and Their Applications

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Luminescent nanoparticles attract a great deal of interest as components in LEDs, displays, biological assays, optoelectronic devices with nanometer dimensions, and as light source in zero-threshold lasers and photonic crystals. Here, we report the synthesis and optical properties of processable Ln^{3+}-doped nanoparticles (5-8 nm), based on insulator and semiconductor materials. Er^{3+}, Nd^{3+}, Ho^{3+}, Tm^{3+}, and Pr^{3+} emit efficiently in the near-infrared when doped in these materials, at 1.55, 1.33, 1.44, 1,44, and 1.44 µm, respectively. Lifetimes are in the µs to ms range. These emissions cover 1300 to 1600 nm, giving the potential of a compact broad-band optical amplifier. The Ln^{3+}-doped semiconductor nanoparticles show sensitized Ln^{3+} emission, i.e. the photogenerated exciton of the nanoparticles interact with the Ln^{3+} ion, leading to energy transfer and thus the excitation of the Ln^{3+} ion. Incorporation of Ln^{3+}-doped water-soluble LaF_3 nanoparticles in sol-gel derived thin films of SiO_2 and Al_2O_3 lead to much more intense emission in the near-infrared than direct doping of these matrices with Ln^{3+}. This approach does also lead to very efficient materials for upconversion of near-infrared radiation into visible. White light has been generated from a single near-infrared light source.

Initial results will be discussed on the influence of a photonic crystal on the luminescent properties of visible and near-infrared Ln^{3+} emitters. A photonic crystal is a period array of different refractive indices with a length scale in the order of light. The result of this is that certain frequencies can not propagate. The general pattern is that the lifetimes of the excited Ln^{3+} is considerably lengthened which may lead for instance to lower thresholds in lasers.

Initial results of these materials in (polymer-based) devices will be discussed. Amplification at 1319 nm has been demonstrated in a polymer-based waveguide based on LaF_3:Nd nanoparticles as the active component. Amplified spontaneous emission has been observed in a microring resonator with LaF_3:Nd nanoparticles in the PMMA cladding.

Dr. van Veggel received his degree in Chemical Technology from the University of Twente (The Netherlands), where he graduated in 1986 under the supervision of Prof. D.N. Reinhoudt. He received his PhD (summa cum laude) in 1990 for his thesis entitled: Metallomacrocycles: Synthesis, Xray Structure, Electrochemistry, and ESR Spectroscopy, for which he was awarded a Shell travel award for the best thesis at the University of Twente. He then joined the photonics research group of the Dutch chemical company Akzo, where he performed research on non-linear optical materials and optical amplification. He supervised a small team that was responsible for the synthesis of new polymers with improved non-linear optical properties. In August 1992 he returned to academia at the University of Twente as an assistant professor and performed research along supramolecular lines in the group of Prof. D.N. Reinhoudt. In July 1998, he was promoted there to associate professor (physical-organic chemistry). He joined the University of Victoria, Canada, in the summer of 2002 as an associate professor with tenure, holding a Canada Research Chair in *supramolecular photonic materials*. In July 2005 he was promoted to full professor. At present, his major interests are in the field of new optical materials and their applications. He is the author of 138 papers and review articles and 7 patents.

Dr. van Veggel is the guest of the Graduate Conference Organizing Committee (GCOC) during his visit to Concordia University. Anyone wishing to meet with Dr. van Veggel is asked to contact Chris Boyer at j_boyer@alcor.concordia.ca or Nabil Al-Yassir at nalyass@alcor.concordia.ca